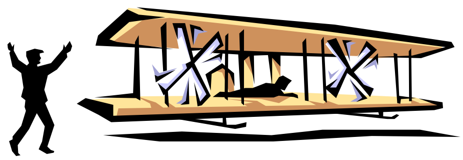
WrightSim

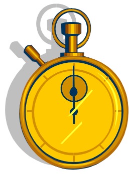


EDUCATIONAL ACTIVITIES

(For Grades 6 – 9)

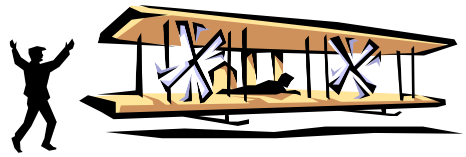
ROGER STORM
NASA Glenn Research Center

2004



ACTIVITY 1 –

“HOW FAST WERE YOU FLYING? “



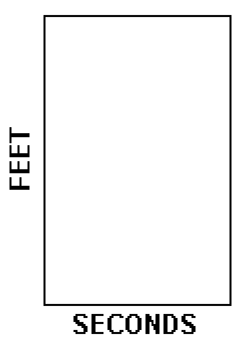
1. Take your turn as pilot of the 1903 Wright Flyer. You should try three flights, recording both the distance and time flow in the place indicated below.

Trial number	Distance Flown (feet)	Time of Flight (seconds)
One		
Two		
Three		

2. Calculate your average distance flown and your average time aloft and record below.

Your Name	Average Distance	Average Time

3. Record your averages on the chalkboard as indicated by your teacher.



4. Take a piece of graph paper and label the left axis (called the Y-axis) “Distance in feet” and label the bottom axis (called the X-axis) “Time in seconds”.

5. Plot each persons average time and distance on your graph. Look at your largest values and make the size of each square on your graph big enough so that all the data can be plotted.

6. Can you see a trend in the plotted points? _________ Use your ruler to draw a line on the graph that comes closest to most of the dots. Remember that you are **not** trying to connect the dots. Draw the best straight line.

7. Looking at the graph, complete this statement:

"As time increases, distance________________________."

8. Now use your average speed, which is in feet per second, and calculate what this would be in miles per hour. To do this you will need to use relationships like "60 minutes per hour" to cancel units that are unwanted in your answer and to leave only the units that you want. If a unit appears in both the top and the bottom of an expression the unit will cancel. If my average speed was 25 feet per second, I would set up problem as shown below:

$$\frac{\text{25 feet}}{\text{1 second}} \times \frac{\text{1 mile}}{\text{5280 feet}} \times \frac{\text{60 seconds}}{\text{1 minute}} \times \frac{\text{60 minutes}}{\text{1 hour}} =$$

9. Now draw a line through the units that appear both in the top and the bottom. When you are done, what units are left? _____________________________

10. To do the math, you need to multiply by numbers in the top and divide by numbers in the bottom. You can ignore the ones. In this example you would do the following:

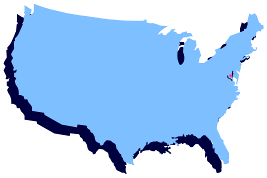
$$25 \times 60 \times 60 \div 5280 =$$

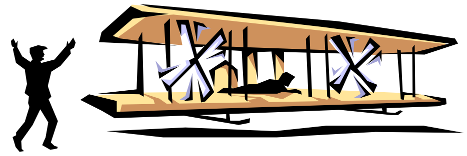
11. Your answer to step 10 should be 17 miles per hour. Now try to change your own value for average feet per second into miles per hour. Show how you did the problem here:

12. Is this a very fast speed? _______________

13. Do you think you could run this fast? __________

14. A professional football player can run 40 yards in 4.5 seconds. How many miles per hour is this?

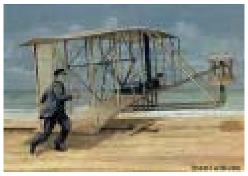




ACTIVITY 2
"WHERE WERE YOU FLYING? "

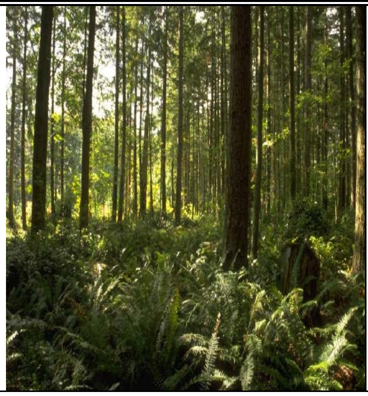
As you lay on the wing as pilot of the Wright Flyer in the simulation, you should have noticed the surrounding landscape as you prepared for take-off. This activity concerns the Wright brother's choice of location to carry out their gliding and early flying experiments. Read the introductory material below before going on to the rest of the activity.

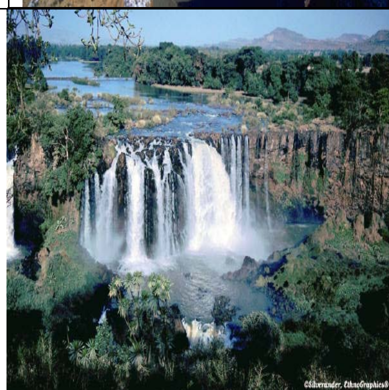
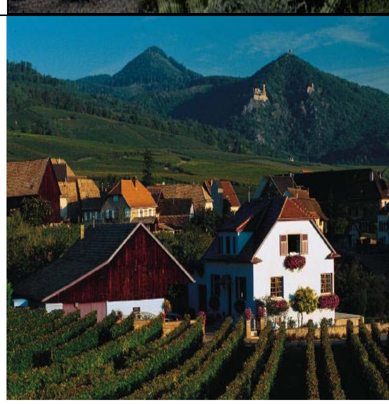
1. In 1899, the Wright brothers were planning to carry out a number of glider experiments. From the best information available, they knew they needed 15 mile per hour winds, which were not available in their hometown of Dayton, Ohio. Wilbur wrote a letter to the National Weather Bureau in Washington D.C. asking for advice. The head of the Bureau answered him personally and sent him two months of reports for all the weather stations in the United States about average wind speed. As you look at this drawing of the 1903 take-off, think about some of the features of the surrounding land that might contribute to either your success or failure.



PART ONE

For each of the pictures in the chart below list features that you might consider good or bad if you were going to be testing low-flying gliders and airplanes.

LOCATIONS		**FAVORABLE CONDITIONS**	**UNFAVORABLE CONDITIONS**
A			

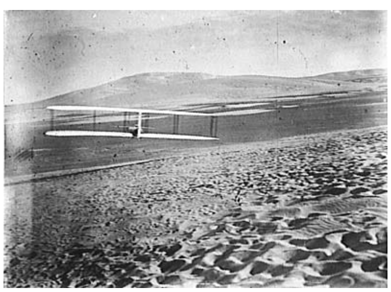
B			
C			
D			
E			

F			

2. Give the letter of the above location that you would you rate as the most favorable for gliding and flying experiments, assuming that all of them had enough wind.________
Why did you make this choice? ____

PART TWO

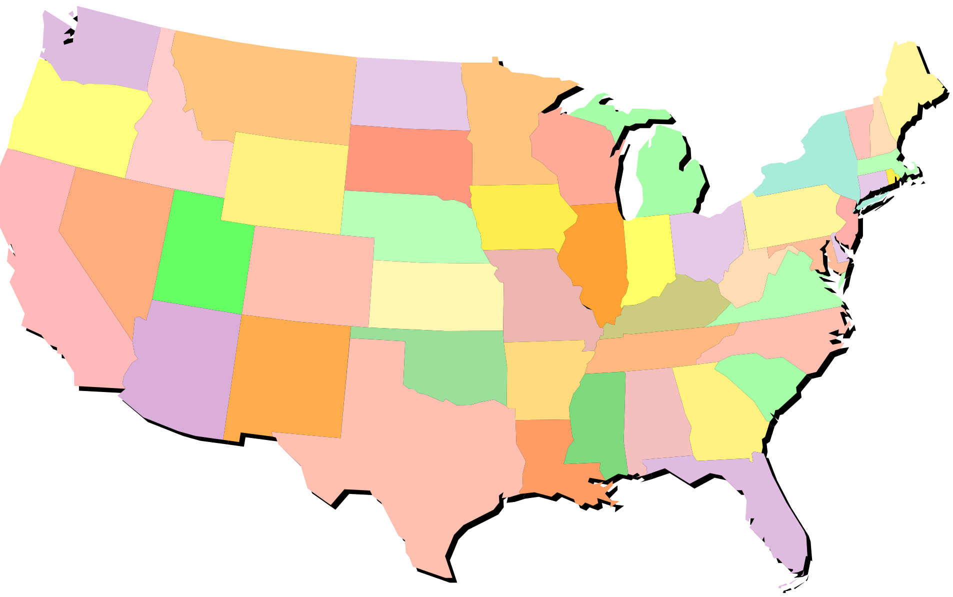
3. Here are some views of the Wright brothers gliding, flying, and their camp which was located on the Outer Banks of North Carolina. The average winds were 15 miles per hour, there were hills for gliding, there weren't many trees, and there was plenty of sand for soft landing. These pictures were taken with Orville Wright's box camera on glass negatives. Some of the negatives, like the bottom center, were damaged in a flood in Dayton in 1913. These are from the Library of Congress collection.





After seeing the Wright's pictures, did your choice in the first part of this activity agree with them? ___________ The Wright brothers went to this place for four years in the summer or the fall for a few weeks to carry out their experiments. They lived in a tent the first trip, but after that they built the buildings you see above. They would launch their gliders from the top of sand dunes into the breezes that blew in from the ocean. In the famous picture of the first actual airplane flight (top row center) the winds were 27 miles per hour!

4. On the map to the right draw a square around Dayton, Ohio and a circle around Kitty Hawk, North Carolina. You may need to look at a U.S. map to find the right places. There are some clues on the next page.



OHIO

NORTH CAROLINA

5. Draw a straight line on the previous map between Dayton and Kitty Hawk

6. Try and determine the distance from Dayton to Kitty Hawk. You can find useful information in the “legend” on a reference map about miles per inch and then use your ruler to measure the map distance. If you have access to the internet, try to use a mapping site such as http://www.mapsonus.com or http://www.mapquest.com
_______________miles

7. In 1903, how do you think the Wright brothers made this trip? Circle all of the ways you think they traveled from the list below.

a. train b. plane c. car d. boat e. horseback f. bicycle

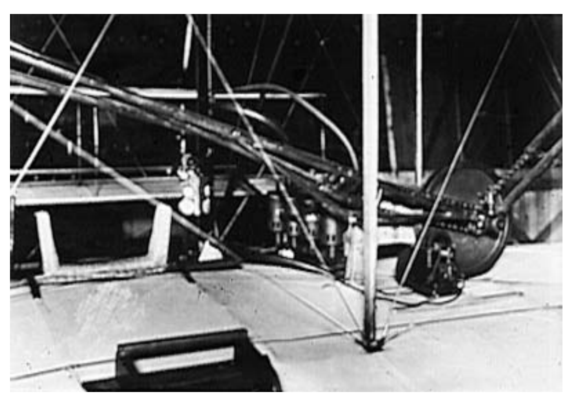
8. On average, about how long do you think this trip would take them?

a. 8 hours b. 15 hours c. 1 day d. 2-3 days e. 5-7 days f. 2 weeks

ACTIVITY 3 – "HOW WAS THE FLYER DESIGNED?"

As you lie on the wing as pilot of the Wright Flyer in the simulation, this is an image of the pilot's view.

Notice that not much solid material makes up this aircraft. It is very open and doesn't look much like an airplane. The construction was a framework of thin wood covered with cloth. This open structure was a necessary feature of the Wright Flyer and is quite different from airplanes today. They are not open at all. Why was the Wright flyer made this way? Let's find out.



1. The Wright brothers built their own engine to power their airplane. As you can see from this picture take from the rear of the flyer, the engine sat on the wing just to the right of where the pilot would lay on the wing. (The "U" shaped part is the hip cradle that allowed the pilot to warp the wings and make the plane turn but shifting his hips left or right.) This

small engine produced 12 horsepower, about the power of two lawnmowers. This is not much power by today's standards but gave enough thrust to allow the Wrights to fly with a strong headwind.

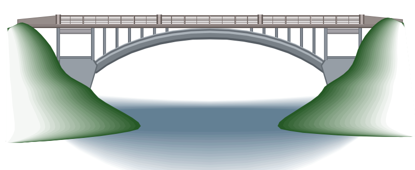
2. What reason or reasons could you give for not making the wings and the struts out of metal or making the plane solid like today's airplanes?

3. Although some of the parts on the Wright flyer, especially the engine, were made of metal, metal parts weigh more than cloth and wood and so were used sparingly. In order to get an aircraft into the air with a small engine the aircraft needs to be as light as possible. Even today's jets with their large, powerful engines are made of lightweight aluminum and have largely plastic interiors to be as light as possible. It is interesting to note that the Wright brothers had the block of their engine cast from aluminum to save weight, an unusual practice in 1903.

4. The open structure, then, was a weight-saving design. This, however, brings up another problem. Wood and cloth are not as strong as metal. In order to withstand the forces of flight, the aircraft needs to be strong as well as lightweight. How do you design an aircraft to be both strong and light-weight? Some solutions are better than others. A glider designed in 1901 by Edward Huffaker to be very light-weight, was made of cardboard tubes. It was sent to Kitty Hawk for the Wright brothers to evaluate. Unfortunately, when it rained the glider was ruined. This was not the best choice of materials.

5. The Wright's answer to how to construct an aircraft was to copy a design that had been used for several years to make glider that braced a thin wood frame with wire. Since wire is metal it is very strong and since it is thin it is also light-weight. The way they connected the wire was based on knowledge gained in bridge-building. A bridge is designed to distribute weight and to carry or transfer the weight to supports on either side.

One way to do this is an arch.



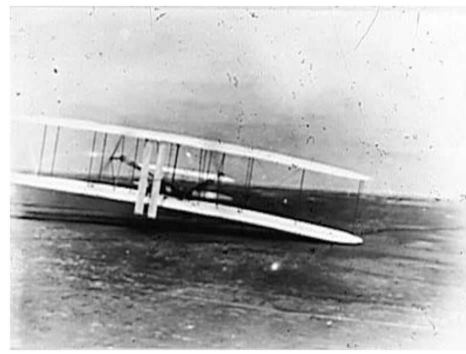
Another solution is to hang the bridge from towers. These are called suspension bridges.

A third solution is called a truss bridge. The  diagonal shaped trusses help to carry the weight.

6. Which of the three bridge designs is most like that used in the early craft like the Wright Flyer?

____

Orville Wright adjusting his 1911 glider.



Third flight of Dec 17^{th}, 1903.

In these pictures you can see the thin wood struts between the wings and the wires used to brace the structure.

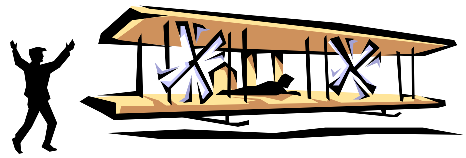
QUESTIONS

1. What are the two most important qualities in airplane construction?

2. Why did the Wrights use cloth wings over a thin wood framework?

3. Describe the design that was used to put these materials together. Why was this kind of construction design used?

4. What kind of structures influenced this design type?

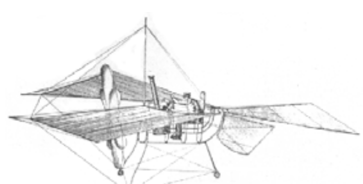


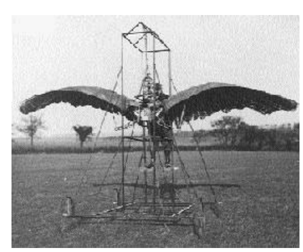
ACTIVITY 4 - "THE NEED FOR INSTRUMENTS"

As you lie on the wing as pilot of the Wright Flyer in the simulation, this is an image of the pilot's view.

Notice that there are some dials on the far right. These are some of the instruments that the Wright brothers used to collect data during their historic flights. The Wright brothers were carrying out scientific experiments. They did not initially set out to build an airplane, but to try and discover way to control an aircraft in the air.

In order to learn from and to modify their experiments they had to collect data. If you experiment and don't collect any data you end up just guessing about what happened or what might happen. Early in the development of aircraft, guessing without making any measurements produced some very odd looking aircraft, none of which successfully flew.

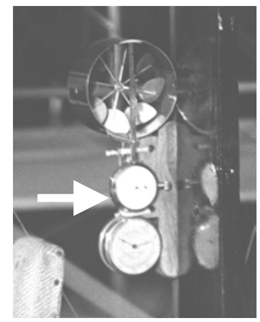




1. Instruments are important in collecting data. When someone drives a car, what information is given by instruments in the dashboard?

____

2. Let's take a look at the instruments that the Wright brothers used. Look again at the picture of the first flight at the beginning of the activity. The top dial is a stopwatch on its side that was used to time each flight, a picture of the actual stopwatch is to the right (Smithsonian Institution negative number 97-16653). The Wright brothers designed a way for the pilot to start and stop the watch remotely. A stopwatch, of course, measures how much time has gone by. The Wright brothers wanted to measure how long they were in the air. The actual first attempt to fly the 1903 Flyer was on December 14, 1903 and Wilbur was the pilot. Since this flight only lasted 3 seconds, they did not feel it counted as a real flight. On December 17th, 1903 Orville flew for 12 seconds and went 120 feet or 40 yards. This was enough time to qualify as man's first successful powered flight.



How does 40 yards in 12 seconds compare with the speed of today's football players? (Refer to Activity #1)____

3. This is a picture of the other device mounted on the 1903 Flyer. It is a "Richard anemometer" (Smithsonian Institution negative number SI 2002-778). Write down your guess as to what you think an anemometer might measure.

____

The following pictures of modern anemometers might be helpful.

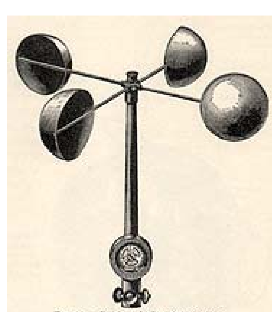
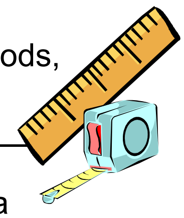


Fig. 66.—Robinson's Cup Anemometer.

4. Did you guess correctly? An anemometer measures wind speed, the higher the wind the faster it will spin. Why was it important for the Wrights to know the wind speed? Based on tests they had done and calculations made, they had determined that the wind speed needed to fly had to be between 22 and 32 miles per hour. With the limited force provided by their small engine and their propellers, a wind of less than 22 mph would not give them enough airspeed to generate enough lift to fly. (Airplanes usually take off into the wind so that they can use the force of the wind to get some of the airspeed needed.) A wind over 32 mph and the drag created by the airplane cancelled lift and they could not fly. They used the anemometer to see if the wind was blowing enough to be able to fly, but not too much.

5. A third measurement that the Wrights took was distance. The four flights made on December 17^{th} were measured at 120 feet, 195 feet, 200 feet, and 852 feet. What instrument would you use to measure these distances? ______________________

One way might be to use a ruler or a yard stick. If they used either of these methods, which do you think might be more accurate? _____________________
Why? ____



6. Two other ways to measure distance would be to pace off the distance or to use a knotted rope. What one piece of information would you need to know in order to pace off the distance? ____

What two pieces of information are needed to measure distance using a knotted rope?

____

Which of these two methods do you think would be more accurate? ____________
Why? ____

7. Finally, distance can be measured by rolling a wheel of known circumference along the path and counting the revolutions. There is some evidence that the Wright brothers used this method on some trials in 1904 when they were flying in Dayton, Ohio. When their plane landed, they put it on a wheeled dolly and rolled it back to the starting point, counting the revolutions of the wheel as they went. If the radius of the wheel was 1 inch and they counted 230 revolutions, how many inches long was the flight? ______________inches (The formula for the circumference of a circle is **Circumference = 2 π r**, where **π** = 3.14 and **r** = the radius of the circle)

Divide your answer by 12 to change it from inches to feet. __________________feet.

Was this equal to their first, second, third, or fourth flight of 1903? _______________

8. Another instrument that was most important to the Wrights was Orville's camera, a Korona V (Shown right, Carroll F. Gray Aeronautical Collection). Although you might not think of a camera as a scientific instrument, it was most important for the Wrights to make a record of their experiments. Why do you think that a photographic record of their gliding and flying experiments would be so important?

This camera was one of the best amateur cameras available. Instead of film, the pictures were all taken on glass plates that were placed inside the camera. What do you suppose was the purpose of the rubber bulb on the left side of the camera?

When the bulb was squeezed, a puff of air is sent through the tube causing the shutter to open and take the picture. Orville did almost all of the photography. On December 17 of 1903, however, Orville was going to pilot the first flight, so he set the camera on its tripod pointed at the end of the take-off rail. He gave the bulb to John Daniels, a member of the nearby lifesaving station who was there helping, and told him to squeeze when the flyer started to take off. What is shown below is the only picture John Daniels ever took, the first flight by man in a powered aircraft.

Orville's camera*   Statue at Kitty Hawk of John Daniels taking first photo

*Courtesy of Carillon Historical Park Dayton, Ohio

QUESTIONS

1. What happens if you try to do an experiment without taking measurements?

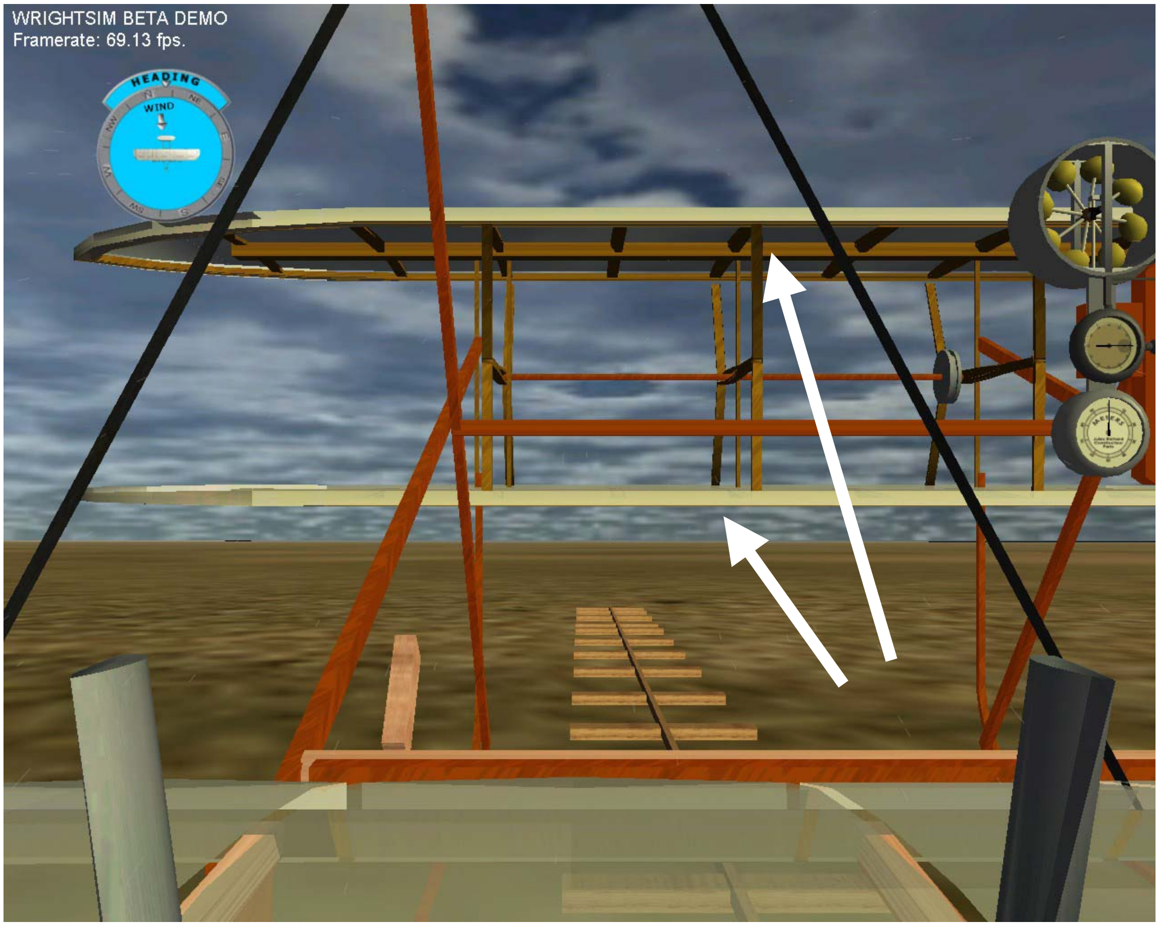
2. What were the two main instruments mounted on the Wright Flyer and what did each measure?

3. Where are two places that anemometers are used today?

4. Why did the Wright brothers take so many pictures?

5. Why are pictures as evidence not as reliable today as they were back in 1903? Think about computers for your answer.

ACTIVITY 5 – "PITCH HAS ITS UPS AND DOWNS "



As you lie on the wing as pilot of the Wright Flyer in the simulation, you can see two moveable surfaces in the front structure of the aircraft (indicated by arrows) that tilt in response to the up and down arrow keys or the forward and back movement of the joystick. The Wrights called these surfaces the "elevator".

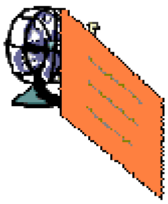
1. You know that an elevator is a device that takes you up or down. This is exactly what the elevators do on the Flyer. They cause the nose of the airplane go up and down. This movement of the nose is called "pitch". You probably know that if you are in a car and you put your hand out the window (not a recommended activity) and rotate your hand from palm down toward palm up, you will feel a force. This force you feel is called "lift" and it is the force that keeps airplanes up in the air.

   The Wright brothers were the first inventors to use moving surfaces on their aircraft to create forces that could be used to control movement in the air. This was their greatest contribution to aviation. But how does it work?

2. It works because turning air generates a force. Take a large, flat piece of cardboard, hold it in front of a fan with both hands on the edge away from the fan, and rotate it in several different directions Note the force or forces you feel on the next page.

If you turn the front edge (near the fan) up, the cardboard is forced ______________________.

If you turn the front edge (near the fan) down, the cardboard is forced ____________________.

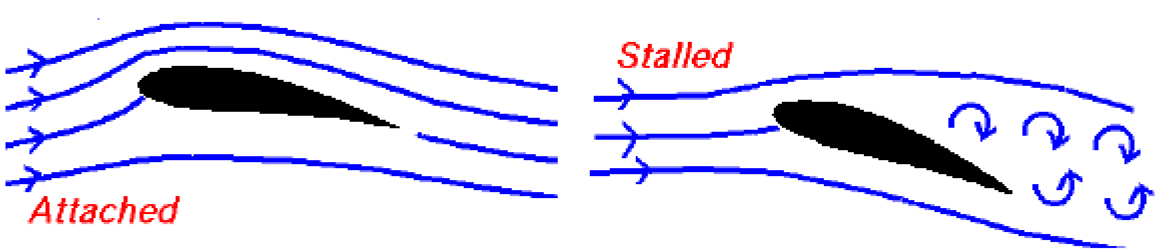


Now rotate the cardboard so it is vertical. If you turn the front edge (near the fan) to the right, the cardboard is forced ______________________.

If you turn the front edge (near the fan) to the left, the cardboard is forced ______________________.

3. Your results from the cardboard show that a force is generated by turning air, and that the amount of force and the direction of the force both depend on the angle of the cardboard. This is how all wings work. They turn air to generate a force in an upward direction which is called lift to offset the downward pull of gravity called weight. If the lift force is greater than the weight, the plane will rise in the air.

4. This angle at which the cardboard faces the fan is called the angle of attack. Flat airfoils like your cardboard and the elevator on the 1903 Flyer generate an increasing amount of lift until they reach about a 10 degree angle of attack at which point the lift force begins to decrease. Beyond 10 degrees or so the angle becomes too steep and the air no longer flows smoothly over the top of the wing as shown in the picture below left, but separates as shown below right. Since the separated air is no longer being turned by the wing, the wing begins to rapidly lose lift. The Wright brothers called this condition a “stall” (which we still call it today) and when this happens the lift becomes less than the weight and the airplane starts to fall.



5. If you have access to the Internet, go to NASA Glenn’s “Beginners Guide to Aeronautics”`

http://www.grc.nasa.gov/WWW/K-12/airplane/incline.html

and investigate the relationship between the angle of attack and the amount of lift generated. Move the slider found near the bottom of the page and then try to answer these questions:

a) What is the lift (in pounds) at an angle of 5 degrees? ____________

b) What is the lift (in pounds) at an angle of 10 degrees? ____________

c) What is the lift (in pounds) at an angle of 15 degrees? ____________

d) What is the lift (in pounds) at an angle of 20 degrees? ____________

e) What is the lift (in pounds) at an angle of -10 degrees? ____________

f) At what angle is the lift 500 pounds? ____________

g) At what angle does the airfoil have the most lift? ____________

h) At what angle does the airfoil start to lose lift and stall? ____________

6. Whether or not you were able to go to the Internet shown above. You can make your own angle of attack device. The directions are in Activity 6 of this series.

QUESTIONS

1. A wing creates a force by ____________________ air.

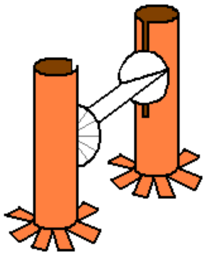
2. The angle at which the wing meets the air is called the angle of _____________.

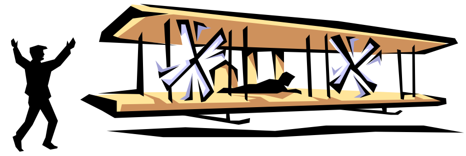
3. When a wing turns air, a force in an upward direction is generated. This force is called _________________________.

4. What happens to this force if the angle of the wing gets too steep?

5. The up or down movement of the nose of an aircraft is called A) yaw B) pitch C) roll D) camber

6. The part of the aircraft that causes the up and down movement of the nose is called the ___________________________.





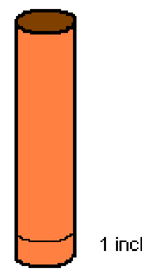
ACTIVITY 6 – "TESTING PITCH ON AIRFOILS"

Since you have tried to fly the 1903 Wright Flyer in WrightSim, you know that it is not easy to fly. It was not easy for the Wright brothers, either. Their success was largely due to the large number of glides they had made in 1902. They had lots of practice.

The difficulty is because this aircraft had a "pitch instability". That means that it was difficult to keep the nose at the correct angle to maintain flight. You know that to do this a 1903 pilot has to control the elevator in the front of the aircraft to keep the proper angle of attack.

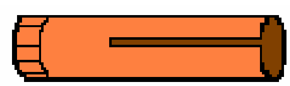
In this activity you are going to construct a device you can use to measure the effect of angle of attack upon the amount of lift generated by an airfoil (wing). Your teacher may already have the tower constructed. In that case you need to start at step #4.

CONSTRUCT THE TEST STAND

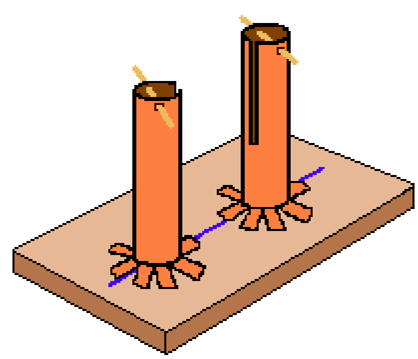


1. Obtain 2 cardboard tubes like those from the center of a roll of paper towels. If the cardboard tubes come from something like wrapping paper, they need to be cut to 11 inches in length. Use a ruler to measure 1 inch from the end of each tube and then draw a ring around the tube at that point. Now draw a line starting at the ring and ending 1 inch later at the end of the tube. Continue to draw these lines one-quarter, one half, and three-quarters of the way around. Now draw a line half way between each of these lines so that you have drawn eight lines in all. Use a scissors to cut each of these lines from the end of the tube up to the ring. Be sure you stop at the ring so all cuts are the same length. Repeat on the other tube.

2. Now you are going to make a slit that runs down the length of each tube. Draw an 8 inch line from the top opening down the length of the tube. Now draw another 8 inch line just ¼ inch away from and parallel to the first line. Use a scissors to cut out the cardboard between the lines as shown. Repeat on the other tube.

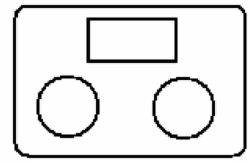


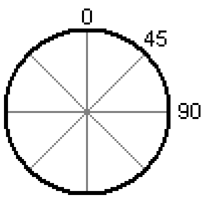
3. Obtain a wood base and a glue gun. BE CAREFUL! The glue gun is hot. Draw a center line across the wood block and glue your two tubes so the slots are on the center line and are 4.5 inches apart. With a paper punch make two holes 90 degrees to the slot and near the top. Use a toothpick or pipe cleaner to slide through the holes. These will stop the airfoil from flying out of the tube during a teat. Use scissors to slit two plastic straws lengthwise and slide them over the edge of the slot that will be farthest from the fan.



CONSTRUCT THE AIRFOIL

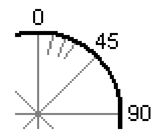
4. Now you need to make a wing or "airfoil" to test. Get a Styrofoam tray and place it face down. Use a compass to draw two circles with 3 inch diameters. Also draw a rectangle 3.5 inches long and 2 inches wide. Use a pair of scissors to cut out these three shapes. Write your name on the rectangle. Throw away the rest of the tray.



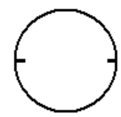


5. Using a protractor, draw a center line across each of the circles that will be zero degrees. Then draw lines for 45 degrees and 90 degrees. Be sure that these lines extend all the way across each circle as shown in the picture to the right.

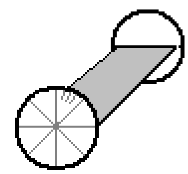
6. Next, use the protractor to make a short mark for 10, 20, and 30 degrees at the edge of the circles.



7. The final construction step is to glue your wing in between the two circles. Use your pen to extend the zero degree line around the edge and then a little bit onto the blank side of each circle. Do this in both directions so now you have two marks on the blank side to show you where to glue your wing.

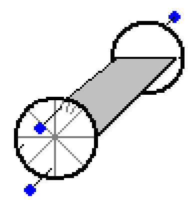


8. Place one circle face down with the blank side facing up. Use the glue gun to fasten your airfoil to this circle. It should be standing straight up and be right on the marks that you made. Let the glue cool and then glue this assembly onto the other circle the same way.

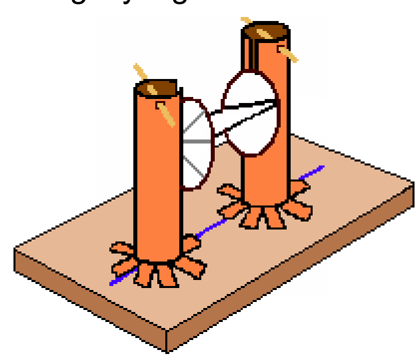


TESTING THE AIRFOIL

9. You will need four pins with a small ball top. Place a pin on the 10 degree mark near the edge of the circle and a second pin exactly across from the first. Repeat on the other circle. Now remove the restraining toothpicks from both tubes, slide the pin heads into the slot of the test stand, and replace the restraining toothpicks. The front edge of your airfoil ought to be slightly higher than the back edge.

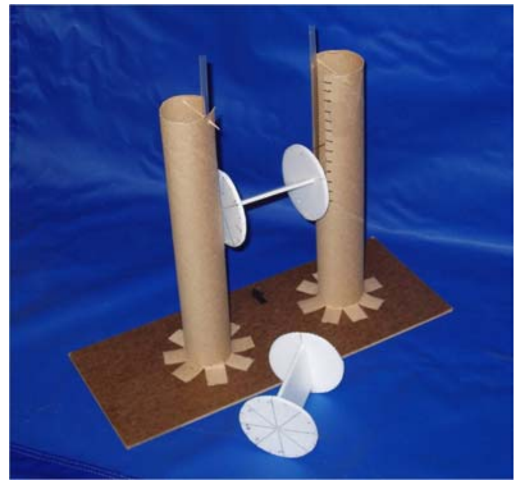


10. Set your test stand at the place in front of the fan as indicated by your teacher and turn the fan to the speed indicated. Gently lift your wing from behind so that it is half way up the slot and then let go and note the results in the chart on the next page.



11. Remove the wing from the test stand and change the angle of attack to 20 degrees by moving all four pins.

Remember that the pins need to stay on opposite sides of the circle. Follow the procedure in step #10.



Your name:______________________________

Test all the angles listed below and note their results.

ANGLE OF ATTACK	RESULT
5 degrees	
10 degrees	
15 degrees	
20 degrees	
30 degrees	
45 degrees	
90 degrees	
0 degrees	
-10 degrees	

QUESTIONS

1. Which of the angles gave the greatest lift? _________________________________

2. Which of the angles gave no lift? ______________________________

3. As the angle of attack got steeper and steeper (more toward 90 degrees) what happened to the lift?____

4. When you were piloting the 1903 Flyer and you pulled back on the elevator control, what happened to your aircraft? _________________ Can you explain this based on your results with your test airfoil? _______________________________________

____

____

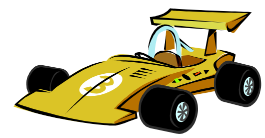
5. What did you learn by doing this activity that might help you become a better pilot on the 1903 Flyer?

____

____

____

6. Race cars often have a wing at the rear of the car called a “spoiler”. Look at the angle on the spoiler. The front edge is below the back edge just like the -10 degree trial. What was the direction of the force generated by the -10 degree angle? (check your data chart) ___________________



So, what direction is the force generated by the spoiler? _____________

7. What is the advantage of having a force acting in this direction on a race car?

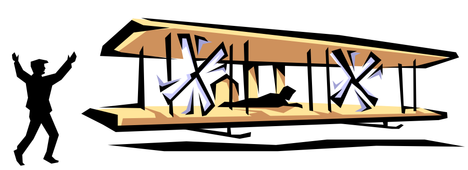
____

Extra Credit: Why is it called a “spoiler”? What does it spoil? (Hint: Race cars are streamlined so they can go faster. Streamlined shapes are wing-like shapes. What will happen to these cars when they start moving very fast through the air?)

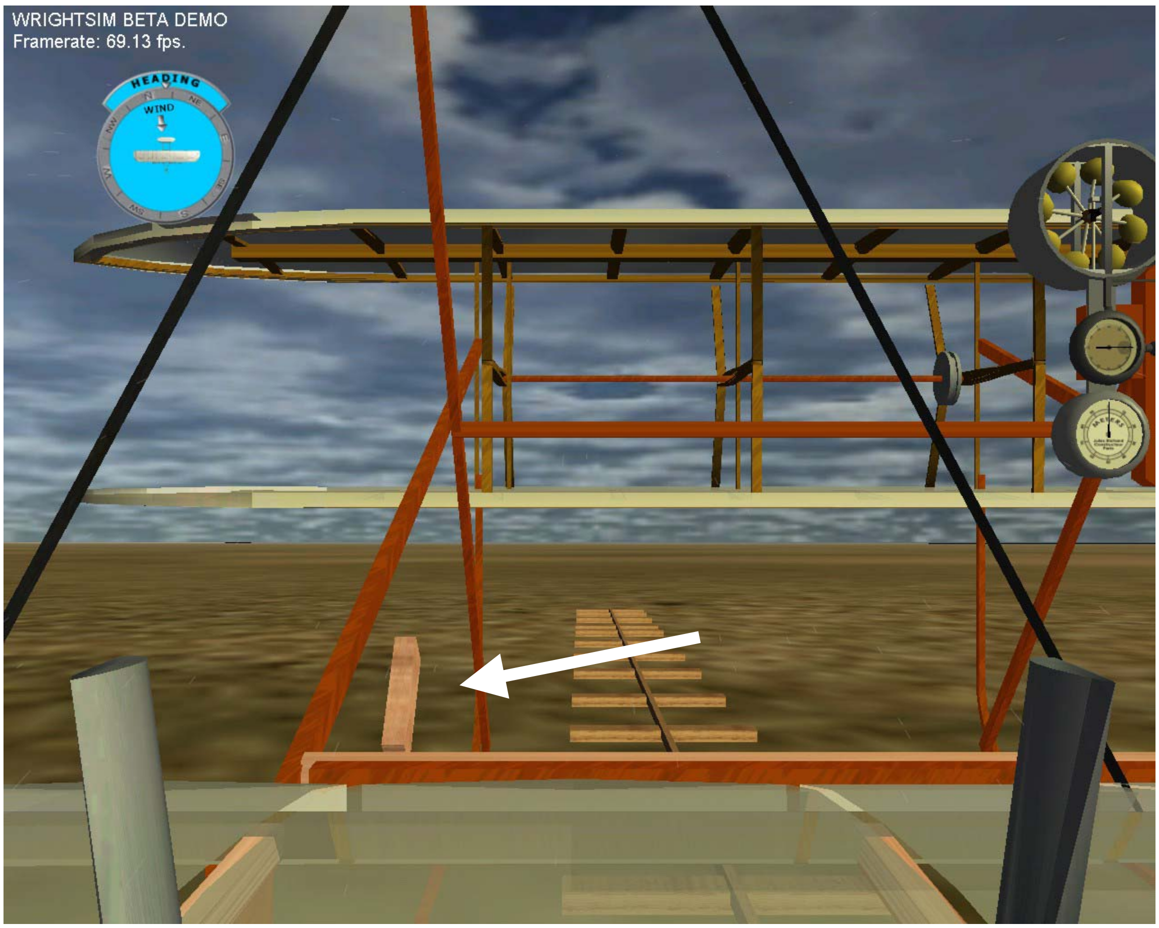
____

____

____

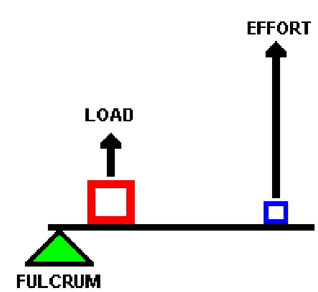


ACTIVITY 7 – “USE THE WRIGHT LEVER”



As you lie on the wing as pilot of the Wright Flyer in the simulation, you can see a piece of wood on the left front, shown by the arrow above. This is the control for the elevator. When you flew the Flyer you may have noticed that the forward movement of the joystick or the upward arrow on the keyboard moved the control forward and the reverse moved it backwards. When this lever is pushed forward or pulled back it causes the elevator to tilt up or down. In this activity you are going to investigate types of lever and how they operate.

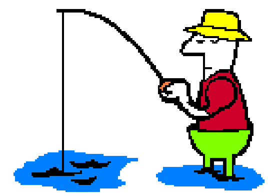
1. Levers always have three parts. First is the **fulcrum**, which is where the lever arm pivots. Second is the **load**, the part that is to be moved by the lever. Third is the **effort**, which is the force applied to the lever.



2. There are three classes, or types, of levers depending upon the location of the three parts.

A. **First Class Levers** - This type has the fulcrum between the load and the effort. An example would be a seesaw or a crowbar. These levers change the direction of the effort and can change either force or distance.

B. **Second Class Levers** – Here the load is between the fulcrum and the effort. A wheelbarrow is a second class lever. These levers always increase effort.



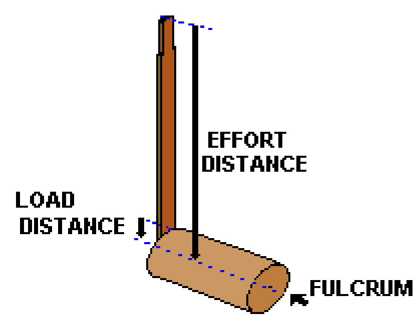
C. **Third Class Levers** – The effort is between the load and the fulcrum. A fishing pole is a third class lever. These always increase distance.

3. For any lever, the amount of work done is determined by the effort that is applied times the distance of the effort from the fulcrum. Work is always conserved, so this value is always equal to the amount of the load times the distance of the load from the fulcrum. For example an effort of 10 pounds acting 4 feet from the fulcrum will move a load of 20 pounds 2 feet from the fulcrum.

Effort x effort arm length = load x load arm length

10 x 4 = 40 and 20 x 2 = 40

The distance the load moves, however is always the inverse of the relationship between the effort and the load. If the load lifted is twice that of the effort applied, then the load will only move one-half the distance of the effort. In the above example, if the effort arm is moved 6 inches, the load will only move 3 inches.



4. This is a diagram of the elevator control arm on the 1903 Flyer where the load is between the effort and the fulcrum.

The elevator control arm is a _________________ class lever.

The effort arm length will be large compared to the load arm length as shown. This means that the load that can be moved by a given effort will be_______.
A) greater than the effort B) less than the effort C) same as the effort

5. The load caused by the wind on the elevator surfaces of the 1903 Flyer was large, so the Wright brothers used a second class lever that increases the effort applied. A smaller force on the handle of the lever resulted in a larger force on the elevators.

QUESTIONS

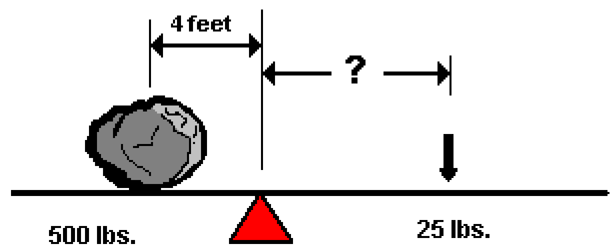
1. There are _____________ classes of levers.

2. The longer the lever, the (greater, lesser) ____________________ the effort needed to move the load.

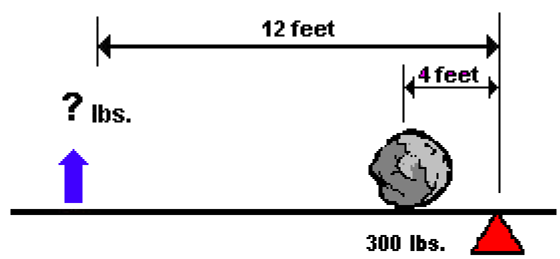
3. The effort times the effort arm length always equals the

    ____.

4. In a first class lever, a rock weighing 500 pounds is 4 feet from the fulcrum. If you can push with an effort of 25 pounds, how far from the fulcrum would you need to push in order to lift the rock?

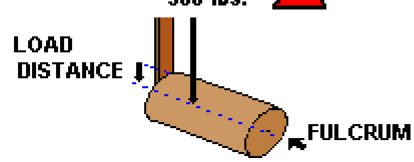


5. In the arrangement to the right a lever is being used to lift a 300 pound rock that is 4 feet from the fulcrum. If you are lifting 12 feet from the fulcrum, how much effort must you apply?



6. What class of lever is being used in question #5? ______________________________

7. If the effort arm distance on the 1903 Flyer was 24 inches and the load arm distance was only two inches, how far would the load move if the effort (Orville's hand) moved 6 inches?



GLOSSARY

AIRFOIL............................... .An object with a special shape that is designed to produce lift efficiently when the object is moved through the air. For example, the cross-section of a wing is an airfoil.

ANEMOMETER .... A device to measure wind speed.

ANGLE OF ATTACK......... The angle of a wing to the oncoming airflow. A pilot pulls back on the control stick to raise the elevator. This causes the aircraft to pitch which increases the angle of attack.

CAMBER.............................The curve of an airfoil.

CIRCUMFERANCE...........The distance around a circle.

EFFORT...............................The force that is applied to a lever.

ELEVATORS ....Control surfaces on the horizontal part of the tail that are used to make the airplane pitch. On the 1903 Flyer they were in front of the aircraft. Pulling back on the control stick will raise the elevators. This causes the aircraft to pitch and increase the angle of attack.

FORCE.................................A push or a pull in a certain direction that can be measured. Examples of forces are your hand pushing on a doorknob, and a propeller pulling an airplane through the air.

FULCRUM ....The point about which a lever pivots.

HEADWIND........................A wind that blows opposite to the direction of travel.

LEVER.................................An arm that pivots about a fixed point called a fulcrum.

LIFT ....A force that is perpendicular to the airflow around an aircraft. In normal, forward flight, the lift force "lifts" the aircraft into the air.

LOAD ....The mass that is moved by a lever.

PITCH ....A rotational motion in which an airplane turns around its lateral axis. Pushing forward on the control stick will lower the elevators, which forces the tail upward. The pilot will then see the nose of the aircraft fall or pitch.

PITCH INSTABILITY ....A design flaw in an aircraft that make up and down control difficult.

ROLL ....A rotational motion in which the aircraft turns around its longitudinal axis. Pushing the control stick to the left will raise the aileron on the left wing and lower the aileron on the right wing. This will cause the airplane to roll to the left. The pilot will see the left wing tip fall and the right wing tip rise. Shifting the hip cradle in the 1903 Flyer caused the wings to “warp” or twist to achieve a roll.

SPOILER ....A device, normally located on the top of the wing, for changing the airflow around a wing to reduce lift. Pilots deploy spoilers when they land so that the airplane is no longer "lifter" into the air.

STALL ....A breakdown of the airflow over a wing, which suddenly reduces lift. When an airplane stalls it will usually drop suddenly. Pilots know how to recover from a stall and smooth out the airflow over the wings to produce more lift again.

STRUTS...............................Upright pieces of wood that support the top wing above the bottom wing.

YAW ....A rotational motion in which the aircraft turns around its vertical axis. This causes the aircraft nose to move to the pilot’s right or left. Pushing the right rudder pedal will tilt the rudder to the right. The pilot will see the nose of the aircraft turn to the right. On the 1903 Flyer this was connected to the hip cradle.

*** Several definitions taken from NASA Quest. For more you can visit http://quest.arc.nasa.gov/aero/wright/tunnels/glossary.html